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63-2-6

FINAL REPORT

THE AMERICAN UNIVERSITY
Washington 16, D. C.

Alfred Weissler, Principal Investigator

"Cavitation Intensity Measurements by Chemical Means"

ONR Grant Number N0001(G)-00055-62

The aim of this project is to develop methods for measuring cavitation intensity on the basis of the chemical changes produced. It was felt that such chemical methods would be a useful supplement to other kinds of cavitation measurements, based for example on sonoluminescence or metal erosion or cavitation noise.

The sonochemical reaction selected for the principal emphasis was the liberation of chlorine in water saturated with carbon tetrachloride; the amount of chlorine produced can be determined by the sensitive color reaction with ortho-tolidine, or else by thio-sulfate titration after addition of starch and potassium iodide.

A simple procedure was evolved for comparing the amounts of cavitation in a 26 kc ultrasonic-cleaner tank under various conditions. Into an ordinary 2" glass test-tube were pipetted 20 ml of water saturated with carbon tetrachloride, plus 1 ml of ortho-tolidine reagent. The vessel was clamped in place in the center of the tank, at such a height that the water level was the same inside as outside the tube. Then the generator was turned on for a specified time interval, usually ten seconds. The intensity of the yellow-orange color produced was measured in a spectrophotometer at 436 mμ wavelength.

Using this method, it was found for example that there is a linear response to equal time-increments of cavitation; also, that the rate of chlorine production becomes greater when the line voltage is increased (which would be expected to give more ultrasonic intensity and more cavitation). With 400 kc ultrasound also, there was a linear relation between rate of chlorine production and plate current in the driver circuit.

Another interesting result with the 26 kc ultrasonic cleaner was that the cavitation was greatest at the center of the horizontal plane of the tank, and fell off rapidly towards the sides, reaching a very low value in the corners. Also, the height of the water in the tank had a large and cyclical effect on cavitation intensity, as if the gradual increase, in the length of the vertical column of water above the transducer, was causing successive tuning and detuning. The height interval between successive resonances corresponded to a half-wavelength of 26 kc sound in water.

Some work was also done on another sonochemical reaction: the conversion of dilute potassium acid phthalate solution (which is not fluorescent under ultraviolet) into a fluorescent substance. It was found that the fluorescence intensity produced was approximately a linear function of the amount of cavitation, much as in the carbon tetrachloride - toolidine method. There appeared to be no significant advantage in this fluorescence method for cavitation measurement as compared with the colorimetric method.

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It was established that the fluorescence was due to the partial conversion of the phthalate into 3-hydroxyphthalate, which is a well-known fluorescent material. Differential spectrophotometry and spectrophotofluorometry were among the techniques used to identify the 3-hydroxyphthalate as a product resulting from cavitation in the phthalate solution. Paper chromatography confirmed this finding, and also indicated that other materials may be formed as well, such as polyhydroxyphthalates. Some work on the chemistry of these reactions is continuing.

A graduate student, Mr. John Marinenko, is the research assistant on the project; during the summer of 1962, a high school senior, Miss Michelle J. Rich, also participated.

A paper on this subject was presented at the Fourth International Congress on Acoustics in Copenhagen at the end of August 1962. Some of the results were included in a paper entitled "A Chemical Method for Measuring Relative Amounts of Cavitation in an Ultrasonic Cleaner" by Alfred Weissler, in the 1962 IRE International Convention Record, Part 6, pp. 24-30 (copy attached).